VEGETATED SAMPLE DISPERSAL AND SMALL UNMANNED AERIAL SYSTEM

OPERATION MANUAL

⚠ READ THIS MANUAL BEFORE USE ⚠

Authors

Roberto Rodriguez, Eszter Collier and Ryan Perroy
Spatial Data Analysis and Visualization Lab
University of Hawai'i at Hilo
Building PB-22
200 West Kawili Street
Hilo, HI 96720

Contents

Forward

The Vegetated Sample Dispersal (VSD) system is designed to operate in conjunction with a small Unmanned Aerial System (sUAS) to disperse vegetation elements for various purposes, such as the *Tectococcus ovatus* biocontrol agent for the eradication of strawberry guava (*Psidium cattleianum*). This document has been prepared to provide instructions for the safe operation and maintenance of the Vegetated Sample Dispersal – small Unmanned Aerial System (VSD-sUAS), and includes proper safety inspections and operating procedures for vegetated sample dispersal. The document also outlines maintenance and servicing procedures for the VSD-sUAS. Before operating this system, please read this manual in its entirety, as well as the manual for the DJI Matric 600 (or equivalent) unmanned aircraft.

Safety Precautions

Basic Requirements

To ensure safety for all equipment and personnel, read this manual thoroughly before use.

The Vegetated Sample Dispersal – small Unmanned Aerial System (VSD-sUAS) is created for the sole purpose of the dispersal of vegetated samples, for various purposes. It is not intended for any other use.

All parts of this system are essential for safe and effective operation. Do not modify any components, or use any parts that are not genuine parts. Failure to follow these guidelines may result in unexpected performance and accidents or other safety concerns.

Operator and Crew Requirements

A VSD-sUAS tree sampling mission requires a minimum of three flight personnel: a pilot-in-command (PIC), a dispersal operator (DO), and a visual observer (VO), although other crew members may be present to assist with the mission. The PIC is responsible for safe operation of the sUAS, including (but not limited to) performing pre-flight inspections, preparing the takeoff/landing area, and maintaining control of the sUAS during takeoff, flight, and landing. The DO is responsible for safe operation of the VSD during dispersal operations. The VO is responsible for maintaining a direct line of sight to the sUAS while the aircraft is in flight and providing broader situational awareness as necessary to assist the PIC and the DO.

Flying the VSD-sUAS system requires a moderate-to-high level of skill. Therefore, it should only be flown by an experienced pilot who holds a current FAA part 107 Remote Pilot Certificate and has >5 hours of flight time, as indicated in a pilot logbook, with a Matrice 600 sUAS or equivalent-sized platform. In addition, any pilot that operates this system should be proficient in the skills required to complete a dispersal mission, as evidenced by a minimum of three successful takeoffs and landings with the VSD-sUAS within the preceding 90 days.

It is imperative to wear proper protective equipment (PPE) when conducting dispersal missions. Required PPE includes:

- Fluorescent safety vest
- Closed-toed shoes with appropriate traction
- Long-sleeved cotton clothing with buttons or other fasteners secured

Sampling Precautions

The VSD-sUAS system is designed to disperse vegetated samples. It is imperative that all dispersal operations are conducted in a safe manner and that bystanders leave the mission area before flights commence. Prior to any dispersal operations, the flight path must be determined to be clear of any

obstructions, including overhead power lines. Continuous clear and verbal communication between the sUAS pilot and the DO is critical for safe and effective branch sampling. Never approach, or allow anyone to approach, within 20 feet of the sUAS during takeoff and landing, or while the aircraft rotors are engaged. Keep takeoff and landing zones clear of any crew members.

Vegetated Sample Dispersal System Components

The VSD-sUAS system (Figure 1) consists of 4 major components:

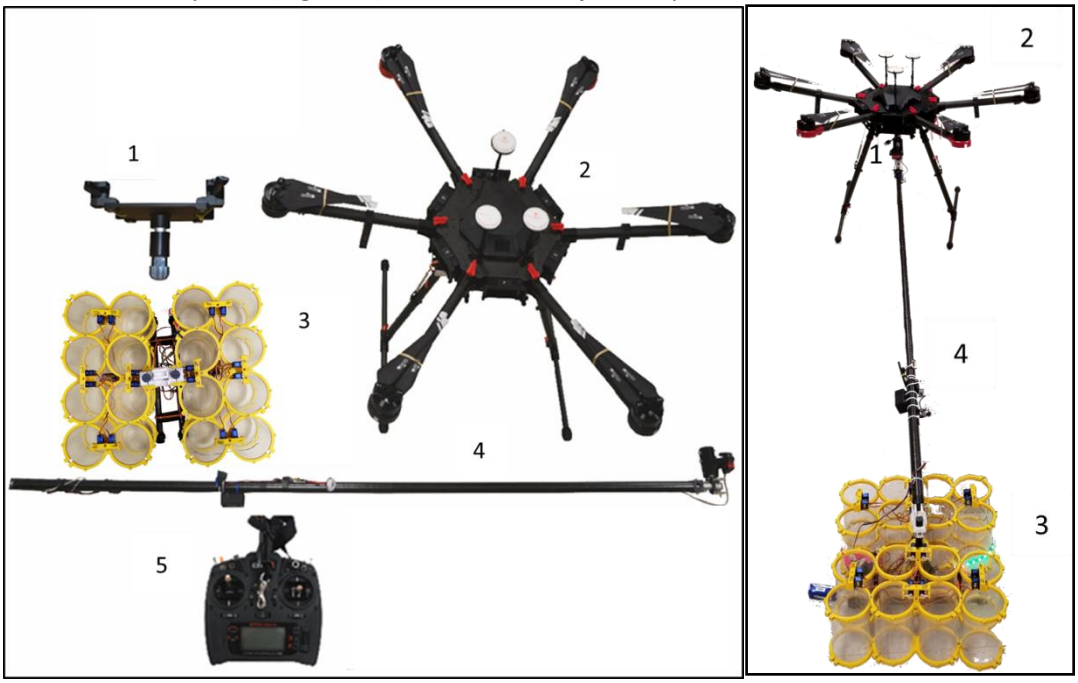


Figure 1. (Left) Individual components, (Right) Assembled TBS-sUAS system. Images not to scale.

(1) sUAS bottom-mount plate and connector
(2) DJI M600 or equivalent sUAS
(3) the VSD
(4) extension pole
(5) VSD radio controller

The VSD system electrical system contains a number of components and is powered by two batteries (Figure 2).

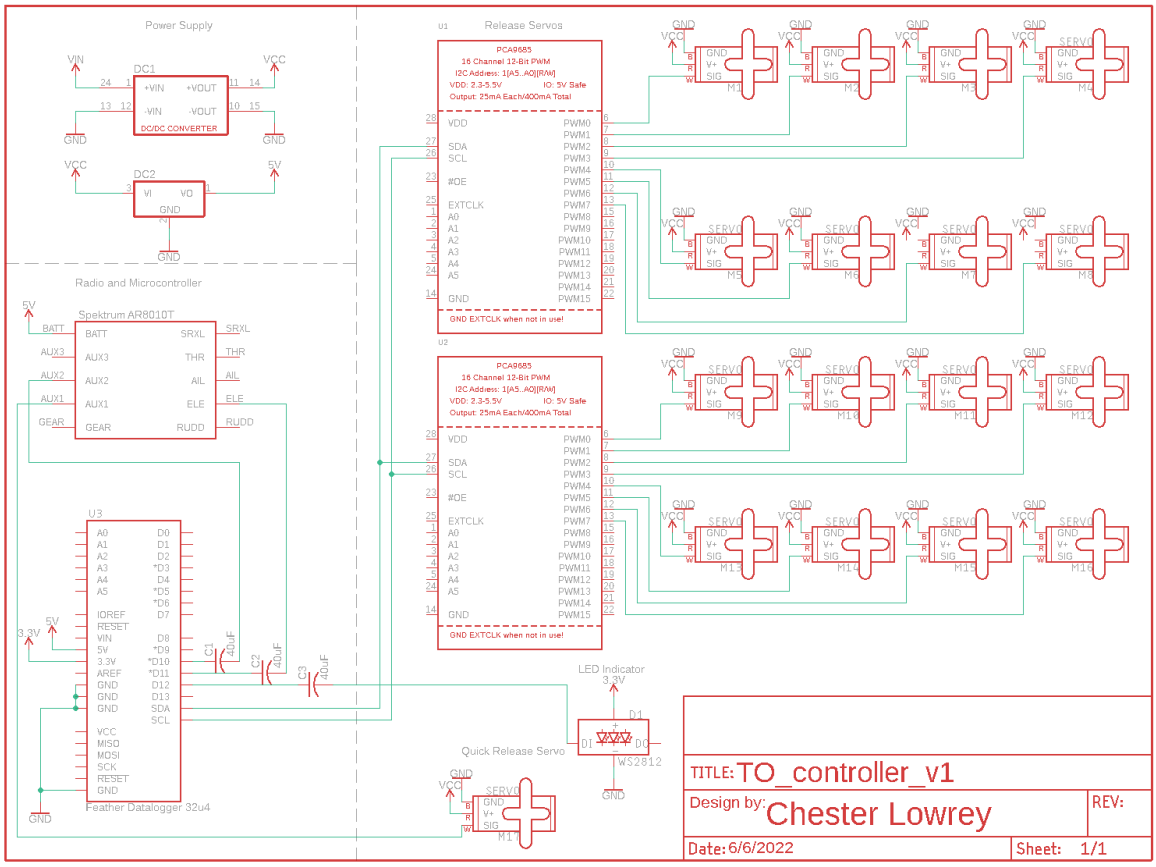


Figure 2. Wiring diagram for the TBS system

The VSD controller contains a switch to control the release servos. The release servo selection is controlled by a joystick to change the currently selected servo. The designated setup for these switch and joystick is shown in Figure 3. All other controller switches are non-functional for the VSD-sUAS system.

The controller must be charged prior to use. The controller must be set to Mode 2, or "VSD," to correctly interface with the VSD system (for more information, see DX8 instruction manual). The VSD controller switches and dials function as follows:

- Right hand joystick – release servo selector
  - Push **up** to select the **next** release servo
  - Push **down** to select the **previous** release servo
- Right hand switch – release servo switch
  - Push **up (towards the operator)** to **open** the release servo
  - Push **down (away from the operator)** to **close** the release servo

Prior to takeoff, all the components must be connected and independently tested to verify that each part can be powered on and that each functions properly via remote control. To test each component, move the controller a distance of at least 50 feet from the VSD and cycle through the full range of motion and/or power settings for each component (see Pre-Flight checklist).

Figure 3. Controller and switch/joystick configurations.

Operational Procedures

Mounting the Vegetated Sample Dispersal System rig to the sUAS

The VSD rig must be securely attached to the sUAS prior to takeoff to ensure safe operation. Position the aircraft so that the underside mount plate is accessible, and make sure that the aircraft is in a location that allows for unobstructed placement of the VSD rig on the ground (a landing pad may be used if needed). Position the extension pole horizontally under the aircraft, with the quick-release mechanism facing the mount plate (Figure 4). Make sure that the quick-release is open (left switch down), and then lift the quick-release mechanism over the hook located on the mount plate. Secure the quick-release mechanism to the mount plate (left switch up; see *Vegetated Sample Dispersal Components* for a description of controller switches). The vertical extension pole should now be attached to the aircraft as shown below, right. To check for secure attachment, gently tug downward on the quick-release mechanism and look for any movement or slippage.

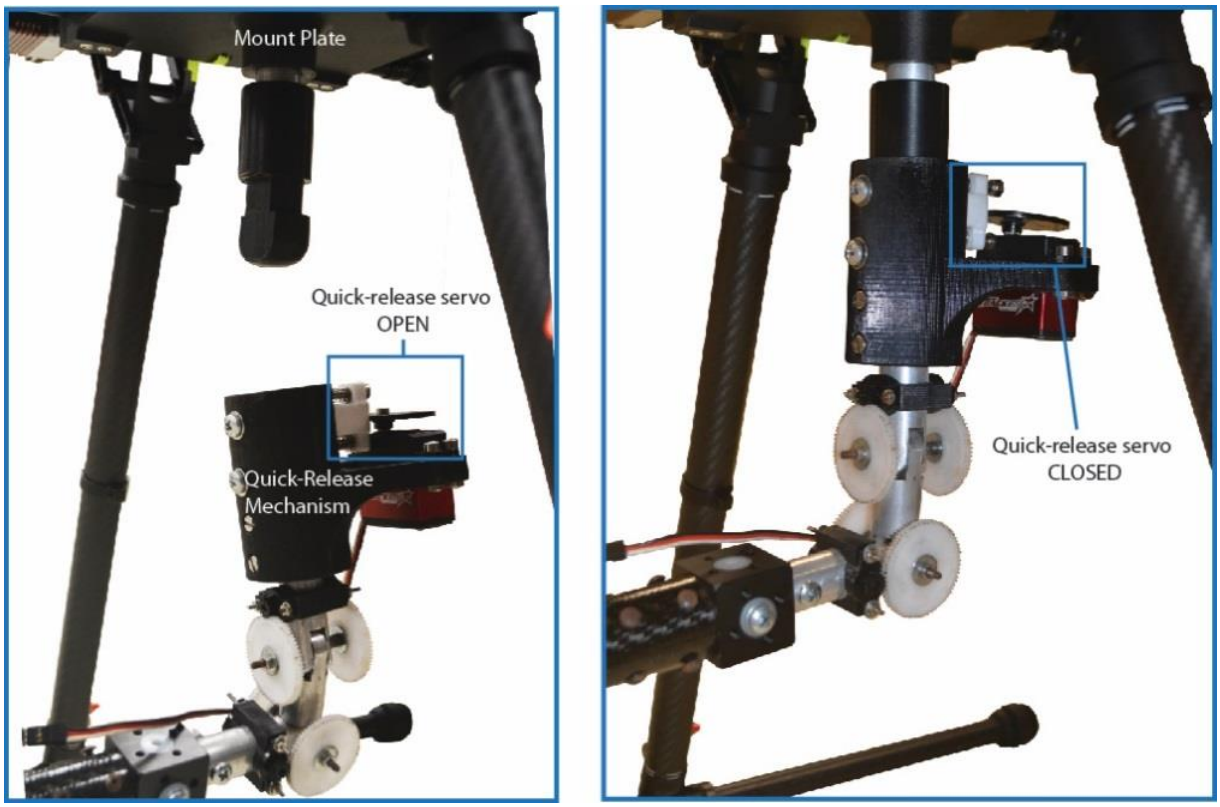


Figure 4. Attachment of the extension pole quick release mechanism

Once the extension pole is secured to the sUAS, connect the VSD to the extension pole via the T-junction on the VSD horizontal channel using the provided Phillips-head screw and locknut (Figure 5).

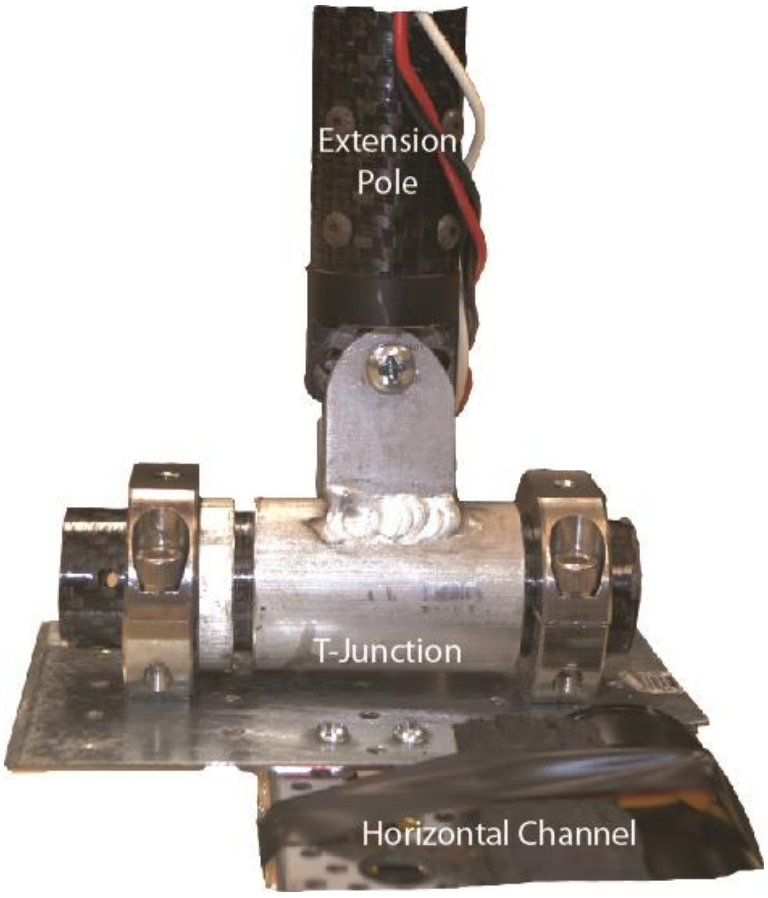


Figure 5. Attachment of the extension pole to the TBS T-junction

Conducting a VSD flight

Pre-flight planning

A safe and successful sample collection flight depends on the coordinated use of all components of the VSD-sUAS system. **Therefore, it is critical to check all electrical connections and verify full function and operator control for all release servos, and quick release prior to takeoff**. Please refer to the pre-flight checklist on page 13 for details.

In addition, check for proper function and pilot control of all sUAS aircraft flight mechanisms (for more information, see the DJI Matrice 600 (or equivalent platform) user manual). The VSD-sUAS should not be operated in inclement weather or in wind speeds > 10 mph.

Flight plans for VSD-sUAS dispersal operations are designed to release up to 16 vegetation samples above the canopy. Therefore, prior to the flight the PIC and VSD operator should agree on the target areas and discuss possible alternative sites in the event that the target area cannot be safely accessed. In addition, an area should be designated by the PIC for post-release rig detachment.

Loading the release servos

The release servos must be loaded individually prior to operation. The operation of all components should be verified prior to loading of the release servos.

Release servo begins in the default closed position.

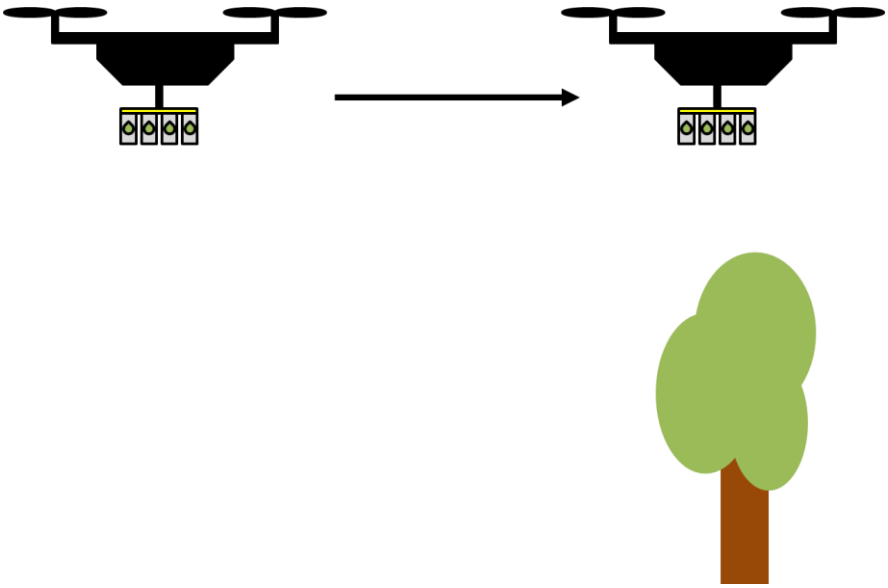
Open the release servo.

Place sample above the arm of the release servo. Ensure the sample does not obstruct any other components of the VSD.

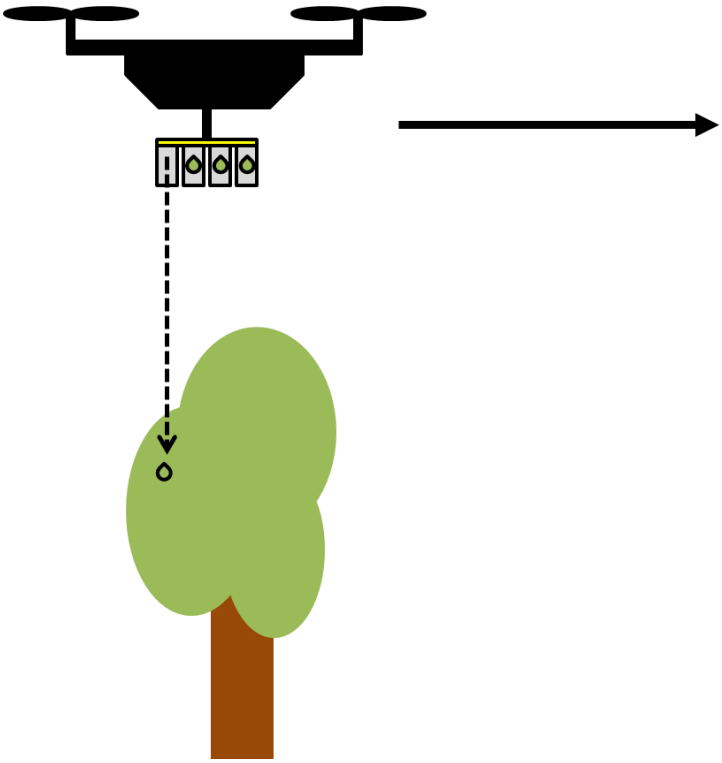
Close the release servo.

Dispersal flight

The pilot is responsible for the operation of the sUAS including aligning the sUAS over the release area. The pilot should choose an approach that is the safest route to the designated release area while allowing the pilot and VSD operator to maintain line of sight between the VSD-sUAS and the designated release area.



Dispersal of the vegetated sample within the designated area requires clear, continued communication between the pilot and the DO. When the sUAS has been positioned at the target area, the DO engages the release servo and visually confirms that the sample has been successfully dropped. After confirming successful release of the sample, the pilot may move the VSD-sUAS to the next dispersal area or the landing area.



Emergency Procedures

The VSD-sUAS system relies on many components functioning together to conduct dispersal mission. Equipment malfunctions or user error may compromise safety and/or successful sample collection.

Loss of power or radio control over components of the VSD

Any loss of power or control for components of the VSD must be addressed immediately. These malfunctions can be caused by loss of radio link between remote control and VSD, loss of battery power to VSD controller, loss of battery power to the quick-release mechanism, or seizing of mechanical parts. If the problem is found to be a loss of radio connection, the pilot may hover while the DO attempts to reconnect to the VSD with the controller. If the problem is not the radio connection, or if connection cannot be re-established, then the pilot must land soon as is it is safe to do so and further troubleshooting must be performed.

Upon the loss of radio link between the remote control and VSD, the release servos will remain in the last state they were in prior to the loss of connection. If the position of the release switch is changed and the radio link is re-established, servo 1 will assume the currently selected state. To ensure that a sample is only release in a designated area the release servo switch should be moved to the **closed** state. .

sUAS malfunction that requires an emergency landing

Reasons to make an emergency landing include (but are not limited to) the following: loss of navigational systems, low battery, loss of radio connection, or mechanical malfunctions. In the event that the aircraft must make an emergency landing, the VSD can be detached mid-air and allowed to drop to the ground. **Prior to opening the quick-release, the DO must verbally inform all crew members of the impending detachment so that they can clear the immediate area**. The pilot and DO must verbally communicate so that the pilot can position the aircraft during descent so as to minimize damage to the VSD when dropped. If the pilot must land immediately and does not have time for proper positioning, the VSD can be dropped from greater heights (although it may be damaged and must be carefully inspected for damage before any subsequent missions).

If the aircraft's automatic return-to-land sequence is triggered, the pilot must resume manual control of the aircraft as soon as it is within the landing area and then proceed with landing.

CREW SAFETY IS PARAMOUNT DURING A DISPERSAL MISSION. In the event that a normal landing is not possible and a crash is imminent, all crew members must be verbally notified to move to a safe distance away from the aircraft's trajectory and the pilot must make all attempts to maneuver the VSD-sUAS away from any people on the ground.

Pre-flight Checklist

- ☐ VSD should be closely inspected for any cracks, loose or damaged parts, or other wear and tear. If any components appear damaged, they must be replaced and tested prior to the flight
- ☐ VSD extension pole securely attached to aircraft using quick-release mechanism
- ☐ VSD secured to extension pole with Phillips-head screw and lock nut
- ☐ All VSD components secured
- ☐ VSD controller is turned on, set to Mode 2 or VSD Mode, and the left joystick is pushed fully DOWN (otherwise controller will give error warning)
    - ❖ Controller is turned on **first**, then 11.1V VSD battery connected
- ☐ All electronic connections are secured and functional via limit testing:
    - ❖ Quick-release battery and controller connection
    - ❖ Release servo controller connection
    - ❖ LED indicator
- ☐ DJI Matrice 600 is properly set up for flight (see DJI manual)
- ☐ VSD release servos are loaded with vegetation samples

Post-flight Checklist

- ☐ sUAS rotors have stopped and aircraft is turned off
- ☐ VSD electronics are disconnected **in the following order:**
  - ❖ VSD 11.1V battery disconnected
  - ❖ Controller turned off
- ☐ VSD should be closely inspected for any cracks, loose or damaged parts, or other wear and tear. If any components appear damaged, they must be replaced and tested prior to the next flight.
- ☐ VSD components that have come into contact with vegetation (release servo and release pod) should be gently wiped down with 70% isopropyl solution to sanitize. Care should be taken to ensure that the solution does not accidentally reach any electrical components or connections.

Vegetated Sample Dispersal System Cleaning and Maintenance

Disconnect all components of the Vegetated Sample Dispersal system from their respective power source before performing any maintenance.

To maintain the VSD-sUAS system in good working condition, regularly inspect, clean and replace any damaged parts (see *Components Specifications* for more details). The sUAS mount plate, vertical extension pole, claw, and saw may be wiped with a soft cloth and 70% isopropyl solution to remove any debris and sanitize external components. Do not apply 70% isopropyl solution to any electronic components or connections or use any other solvents or liquids to clean the VSD, as doing so may damage the electronic circuitry.

For information regarding DJI M600 (or equivalent) sUAS maintenance, please refer to the aircraft's user manual.

VSD Specifications

Model	V1
Weight	10.2 lb
Maximum payload weight	2 lbs
Maximum number of vegetation samples	16
RC control frequency	2.4 GHz

Component Specifications

Release Servo

Weight	0.32 oz
Supply Voltage (Vin)	4.8 V
PWM Logic Voltage	5.0 V
Stall Torque	8.9 lb./in.
Operating Speed	0.1 sec/ 60°

Radio Telemetry Receiver

Weight	0.63 oz.
Type	DSMX with internal telemetry
Number of Channels	8
Modulation	DSM2/DSMX
Band	2.4 GHz
Voltage Range	3.5-9 V